IN THE SPECIFICATION:

Please replace the paragraph beginning on page 1, line 13 as follows:

The present invention relates generally to a reaction stimulator and energy converter ~~an energy generator and more specifically to a method and apparatus to couple the excitation structure of a semiconductor substrate to the excitation structure of reactive adsorbates on the surface of a catalyst~~.

Please replace the paragraph beginning on page 5, line 27 as follows:

A theory to use ~~a~~ solid state metal-insulator-metal junctions to produce resonantly coupled, hot electrons has been proposed. The theoretical suggestion would produce resonance-assisted, hot-electron-induced femto-second chemical processing at surfaces. The energies relative to the catalyst Fermi level and associated with the metal-insulator junctions is higher than what is now known to be appropriate for surface resonances. No experiments using this theory are known at this time. No known mention of process reversibility has been claimed.

Please replace the paragraph beginning on page 6, line 3 as follows:

The use of a neutral semiconductor substrate as the injection mechanism into thin metal overlayers, with photons derived from a pulsed laser as the creator of hot carriers in the semiconductor, was also suggested in the literature. It was suggested that this could be an order of magnitude more efficient for stimulating gas-surface catalytic reactions than using the metal as the photon acceptor. It was suggested that using a semiconductor substrate, metal overlayer and catalyst device to produce hot electrons more efficiently with photons and inject them into a catalyst surface. ~~A critical detail~~ However, process

efficiency needed to render the ~~process efficiency~~ approach useful was not adequately addressed ~~in a way needed to assure process efficiency~~. One must tailor the Schottky junction, the ohmic junction or the almost ohmic junction between the semiconductor and the metal so that the coupling of either hot carriers such as hot electrons or holes is electrically efficient, or so that the resonant tunneling is efficient. The proper use of resonant tunneling and resonance-assisted processes can be valuable components in a useful device and method.

Please replace the paragraphs on page 7, line 33 to page 10, line 17 as follows:

~~The present invention is directed to a method and apparatus to couple the excitation structure of a semiconductor substrate to the excitation structure of reactive adsorbates on the surface of a catalyst. Preferably, the coupling is reversible. The reversible reactor uses excitations originating in a semiconductor substrate to stimulate chemical reactions by the adsorbate species on the surface of a catalyst, and uses the reverse process to generate excitations in the substrate as the result of reactions. The method and apparatus when operated in the stimulator mode uses electrical or other forms of energy input to the semiconductor substrate to manipulate the reaction path so as to accelerate reactions, to steer the reactions, to manipulate the forms of energy produced by the reaction, and to reduce the temperature needed to stimulate surface catalytic reactions; when operated in the generator mode the apparatus converts excitation energy of the adsorbate catalyst system into electricity or other forms of energy in the semiconductor substrate; and when operated in the stimulator generator mode, may use electricity or other forms of energy to manipulate reactions and at the same time may generate electricity or other forms of energy from the adsorbate catalyst system chemical~~

reaction energy.

In the present invention, electricity or other forms of energy are used to create and inject excitation energy, such as hot carriers, into adsorbates on a catalyst surface and to stimulate adsorbate surface catalytic reactions; and, because of the reversible nature of the process, one and the same type of apparatus may also be directed to collecting excitations that result from surface chemical reactions, such as hot carriers in a semiconductor substrate, and converting them into electricity or other forms of energy. In an exemplary embodiment, the present invention uses electronically energized semiconductor diodes in a novel way to stimulate the reactions. For example, in one embodiment, the present invention utilizes a p-n junction as the creator of hot carriers and as the injection mechanism to couple them into thin metal overlayer structures of catalyst material and to adsorbates on the catalyst surface. The same embodiment may use the same p-n junction to collect hot carriers in the semiconductor diode, forward biasing it and hence generating electricity.

The present invention includes a hot carrier emitter, also known as an excitation emitter, in intimate contact with a catalyst ensemble energy collector also known as a catalytic collector. The excitation emitter includes a semiconductor diode.

When the apparatus is operated in the stimulator mode, electrical or other energy input to the semiconductor diode causes it to generate excitations such as an excess of holes or electrons, and the resulting hot carriers and resonantly coupled excitation energy is coupled to and absorbed by the excitation structure of a catalyst adsorbate system, thereby stimulating adsorbate chemical reactions.

When the apparatus is operated in the generator mode, excitation energy originating in a catalyst adsorbate system is

~~coupled into semiconductor band excitations, which can typically cause a forward bias in the semiconductor and generate electricity or other useful forms of energy.~~

~~The semiconductor diode includes an emitter, a diode junction and a semiconductor base. The emitter, which is in intimate contact with the catalytic collector, includes a semiconductor when the diode is a p-n junction diode, or the emitter includes a metal when the diode is a Schottky diode. The junction is the region of contact between the emitter and the base. The emitter also includes an electrical contact. When the hot carrier, semiconductor excitation, is chosen to be an electron then the base includes an n-type semiconductor and the emitter includes either p-type semiconductor or a metal. When the hot carrier is chosen to be a hole, the base includes p-type semiconductor and the emitter includes either n-type semiconductor or a metal. The base also includes an electrical contact.~~

~~The catalytic collector is placed in intimate contact with the emitter and includes a catalyst, an optional underlayer, and optional reaction accelerator decelerator materials. Elements of the catalytic collector may be one and the same with elements of the emitter. A surface of the catalyst and of the optional reaction accelerator decelerator materials comes in intimate contact with the reactant chemicals.~~

~~Various regions of a device using this invention may include various and different catalytic collectors, hot carrier emitters and various modes of energy coupling, including ballistic transport and resonant tunneling.~~

The present disclosure, in one embodiment, is directed to a method and apparatus to couple the excitation structure of a semiconductor substrate to the excitation structure of reactive adsorbates on the surface of a catalyst. The coupling is then used to stimulate reactions and to extract energy from the

reactions.

In one embodiment, the method and apparatus injects energy such as hot electrons, from a substrate, into a catalyst, and through the catalyst to the catalyst surface. At the same time, reactants are conveyed to the catalyst surface from a gas phase in contact with the surface. The reactants adsorb on to the catalyst surface and become adsorbates.

In an exemplary embodiment of the present disclosure, hot electrons constitute the injected energy. The method and apparatus of the present disclosure uses the hot electron energy to initiate, to control and/or to drive reactions of the adsorbates. Reaction products react, desorb and/or diffuse on or away from the catalyst surface.

The method of injecting energy such as hot electrons into adsorbates may have the unique result of driving reactions that cannot be driven by the use of heat energy alone. The products of the driven reactions may themselves constitute the desired reaction product.

This mode of operation may also include causing and tailoring reactions in the volume of a gas phase in contact with the surface as well as on the surface of the substrate, by using desorbed products. The products of the driven reactions can be used to drive and control other reactions.

In one embodiment, the method and apparatus of the present disclosure may use two-terminal devices such as semiconductor diodes to inject hot electrons. The method and apparatus may also include using a conducting catalyst to form one of the terminals. The thickness of the conducting catalyst terminal is formed to be sufficiently thin to permit the transport of useful number of the hot electrons to the reactive surface of the catalyst.

In another embodiment, the method and apparatus of the present disclosure may use chemical reactions on or near a second

surface to generate hot electrons. The method and apparatus may include transporting the hot electrons to the catalyst surface containing adsorbates.

The second surface may be in contact with a substrate, which is in turn in contact with the catalyst surface. This mode of operation and its variants are referred to as the stimulator mode.

The method and apparatus of the present disclosure may operate in reverse, where reactions of adsorbates on or near the catalyst surface release energy that is collected into a useful form. One form of energy is hot electrons which travel into the catalyst, through the catalyst and into a substrate. Other forms of energy may include electromagnetic radiation. This mode of operation and its variants are referred to as the generator mode. The method and apparatus to couple excitation structures, in one embodiment, includes operating in both modes at the same time.

The method and apparatus of the present disclosure may use hot holes instead of hot electrons, referring to either hot holes or hot electrons as hot carriers and also as energetic excitations.

In one embodiment, the method and apparatus in the stimulator mode includes stimulating reactions that comprise creating hot carriers and injecting them into the catalyst. For example, the method and apparatus in one embodiment uses a two terminal device such as a forward biased p-n junction diode or a Schottky diode to create hot electrons. Diode electrons flow in the direction of the forward bias. An electron starts at the terminal biased negative on the back side of a substrate semiconductor. It travels through the semiconductor and out of the semiconductor into the positively biased part of the diode.

When the electron transitions to the positive part of a p-n junction diode, it becomes a minority carrier with energy approximately equal to the band gap energy and is therefore

"hot." When the electron transitions to the positive part of a Schottky junction diode, which is a conductor, the electron has approximately the forward bias energy, and is also therefore "hot."

If the positively biased terminal and the positive part of the diode are thick relative to the energy mean free path of the hot electron, then the hot electron may loose energy in the positively biased regions and the energy may be lost to heat. This typically occurs within tens of femtoseconds and within tens of nanometers in a metal. The method and apparatus, in one embodiment, thus includes forming the positively biased parts and terminal of the diode to be thin, thin relative to the energy mean free path of the hot electron.

When the positively biased terminal of the diode is in direct contact with a metal catalyst that is also thin relative to the energy mean free path of the hot electron, the hot electron passes from the diode, through the positively biased terminal of the diode, through the catalyst and on to the surface of the catalyst. The method and apparatus, in one embodiment, thus includes forming a suitably thin catalyst in direct contact with the positively biased parts and terminal of the diode.

When hot electrons are driven onto the surface of the catalyst, adsorbates on the catalyst can be stimulated to react. Reactions may occur within picoseconds of the appearance of the hot electrons. Some reactions may go to 80% completion less than a picosecond.

When the surface of the catalyst is in contact with a liquid, the hot electrons may dissipate into the liquid, greatly diminishing their ability to cause reactions. The method and apparatus, in one embodiment, thus includes providing a gas phase, rather than a liquid phase, in contact with the catalyst.

Generally, the excitation structure of a semiconductor substrate is represented by its energy levels. The valence and

conduction bands are such energy levels. The energy levels of a quantum well are such energy levels. Excitations may include minority carriers, hot carriers, coupling electric fields associated with electromagnetic cavities, excitons, and plasmons. The excitation structure of reactive adsorbates on the surface of a catalyst may include excited reactant molecular vibrations, molecule-surface vibrations, atom-surface vibrations, adsorption reactions, chemical reactions, excited electronic states, and the energy levels of the adsorbate-substrate system.

The method and apparatus when operated in the stimulator mode, in one embodiment, uses electrical or other forms of energy input to the semiconductor substrate to, for example, manipulate the reaction path of the adsorbates so as to accelerate reactions, to steer the reactions, to manipulate the forms of energy produced by the reaction, and to alter the temperature needed to stimulate surface catalytic reactions.

The method and apparatus when operated in the generator mode, in one embodiment, converts excitation energy of the chemical reaction associated with the adsorbate-catalyst system into electricity or other forms of energy in the semiconductor substrate.

When operated in the stimulator-generator combined mode, the method and apparatus, in one embodiment, may use electricity or other forms of energy to manipulate reactions and at the same time may generate electricity or other forms of energy using the chemical reaction energy released by the adsorbate-catalyst system.

In one embodiment, the method and apparatus of the present disclosure in the stimulator-generator mode uses a p-n junction to create hot electrons and inject the hot electrons into thin metal overlayer structures that may include catalyst material. By conveying the hot electrons to adsorbates on the catalyst surface the method stimulates a reaction that can, for example, create an

abundance of autocatalyst reactants on the catalyst surface.

An example of such an autocatalyst is the OH, hydroxyl radical. The autocatalysts cause an avalanche of further stimulated reactions on or near the catalyst surface. These reactions create hot electrons in the catalyst. The same p-n junction diode may collect the hot electrons forward biasing it and hence generating electricity. In another embodiment, a Schottky diode may be similarly used.

In one embodiment, when the method and apparatus of the present disclosure is operated in the generator mode, excitation energy originating in a catalyst-adsorbate system is coupled into semiconductor band gap excitations, which can typically cause a forward bias in the semiconductor and generate electricity or other useful forms of energy.

The catalyst surface and the positively biased terminal may include a catalyst, an optional underlayer, and optional reaction accelerator-decelerator materials. A surface of the catalyst and of the optional reaction accelerator-decelerator materials comes in intimate contact with the reactant chemicals in one embodiment.

Various regions of a device using the method and apparatus of the present disclosure may include various and different catalysts, various different, hot carrier emitters and various modes of energy coupling, and may include electromagnetic coupling, plasmon coupling, ballistic transport and resonant tunneling.

Please replace the paragraph beginning on page 10, line 33 as follows:

Figure 2 illustrates a cross section of a catalytic excitation collector in one embodiment of the present invention;

Please replace the paragraph beginning on page 11, line 1 as

follows:

Figure 3 shows a cross section of a reaction stimulator device with catalyst clusters forming the catalytic excitation collector;

Please replace the paragraph beginning on page 11, line 4 as follows:

Figure 4 shows a cross section of a solid state surface catalysis reactor device with a thin electrode forming a substrate for catalyst clusters as part of a catalytic excitation collector and also forming the electrical connection for the hot carrier emitter;

Please replace the paragraph beginning on page 11, line 13 as follows:

Figure 6 illustrates a cross section of the solid state surface catalysis reactor having a single metal element that is at the same time an electrical connection to the emitter, the underlayer of the catalytic excitation collector and forming the metal element of a Schottky diode; and

Please add the following new paragraph before paragraph beginning on page 11, line 24:

In one embodiment, the method and apparatus of the present disclosure uses hot electron energy to initiate and or simulate chemical reactions which would otherwise not occur by thermal processes alone. The non-thermal, hot electron energy tailors reaction paths between adsorbates and gas reactants interacting with a catalyst surface. One source of hot electrons is the reaction of fuel and oxidizer on a catalyst structures. Another source uses two terminal electrical devices in contact with the catalyst surface. Electricity can be generated using the same method and device from the pulsed reactions stimulated by hot

electron injection. In one embodiment, the method and apparatus couples the excitation structure of a semiconductor substrate to the excitation structure of reactive adsorbates on the surface of a catalyst. The coupling is used, in one embodiment, to stimulate reactions and/or to convert chemical energy into a useful form.

Please replace the paragraph beginning on page 11, line 25 as follows:

~~An exemplary embodiment of the present invention~~ In one embodiment, the method and apparatus of the present disclosure uses electrons as the hot carriers and a p-n junction diode as the semiconductor diode. The base, or substrate, is n type semiconductor and the emitter of the hot electrons is ~~an~~ p type semiconductor. A forward bias on the p-n junction diode injects minority carrier electrons into the conduction band of the p type ~~emitter~~ region where they become minority carriers. The minority carriers diffuse and migrate to the catalytic excitation collector and may also be resonantly coupled into the excitation structure of the adsorbate-catalyst system, for example, if ~~provided that~~ the distance from the junction to the catalytic excitation collector is less than several times the diffusion length of minority carriers in the p type semiconductor. For example, when InSb, InAs, or some alloy of InGaAsSb is the semiconductor, then the diffusion length can range from approximately 100 nanometers to several microns.

Please replace the paragraph beginning on page 12, line 6 as follows:

According to an embodiment of the method and apparatus of this disclosure ~~this invention~~, the minority carrier electrons are injected or resonantly coupled into the ~~catalytic collector~~ catalyst with an energy in excess of the Fermi level of the

catalyst ~~catalytic collector~~. This excess energy is nearly mono-energetic and has a value approximately equal to the forward bias on the diode. When the semiconductor is a p-n junction diode, the minority carrier energy may be within approximately several kT of the semiconductor band gap energy (kT = thermal energy, 0.026 eV). When the semiconductor diode is a Schottky junction the carrier energy may be within approximately several kT of the energy needed to overcome the Schottky barrier. The ~~electrons with forward bias energy, also called~~ hot electrons~~,~~ may rapidly permeate on to a surface of the catalyst facing and in intimate contact with reactants if, for example, the distance from the p type semiconductor to the surface in contact with the reactants is less than the several times the energy mean free path of electrons in the catalytic excitation collector.

When the catalyst is a metal such as platinum, palladium, rhodium or ruthenium the energy mean free path ranges between 5 and 50 nanometers. When the underlayer is copper or gold the energy mean free path ranges between 50 and 200 nanometers.

Please replace the paragraph beginning on page 12, line 25 as follows:

When the catalyst is a metal such as platinum, palladium, rhodium or ruthenium the energy mean free path ranges typically between 5 and 50 nanometers. When the underlayer is copper or gold the energy mean free path ranges typically between ~~5~~10 and 200 nanometers.

Please replace the paragraph beginning on page 12, line 30 as follows:

The flux of hot electrons interacting with the reactant chemicals is approximately that of the diode forward current if the distance from the catalytic excitation collector to the diode junction is within the diffusion length of the emitter

semiconductor and energy mean free path lengths of the catalyst and underlayer, as specified herein. ~~Hot electrons interact strongly with adsorbates.~~

Please replace the paragraph beginning on page 13, line 3 as follows:

Another aspect of the present invention uses a Schottky diode. Typical Schottky diode barriers are 0.5 eV and above. For example, when an unacceptable diode barrier forms between desired conductors and semiconductors, a Schottky diode designed to have an effective low barrier height, also referred to as a tunneling junction, may be used. Such a device is constructed by choosing the doping between the metal and the semiconductor of the Schottky junction to be intermediate between the very high doping used to make an almost ohmic junction, typical for making electrical contacts with the semiconductor, and the medium doping used to make a normal Schottky diode. The doping controls the width of the depletion region and hence the strength of the Schottky barrier. The value of the doping may be chosen between degenerate or high doping and conventional or moderate doping, depending on the application.

Please replace the paragraph beginning on page 13, line 16 as follows:

When the semiconductor is silicon and the metal is any metal associated with the catalytic excitation collector then the doping may be adjusted to an effective value of order 0.1 eV. High doping in silicon yields effectively 0.0 eV barrier and normal doping yields barriers typically between 0.5 and 1.5 eV barrier. This tunneling junction Schottky diode permits the use of common semiconductor materials such as silicon. The use of such a diode is appropriate for use in the generator mode where reactions are pulsed.

Please replace the paragraph beginning on page 13, line 25 as follows:

With the methods and apparatus provided in either the p-n junction diode or the Schottky junction embodiment of the present invention, the semiconductor diode injects hot carriers or resonantly couples the carriers and with energy approximately equal to the energy of the diode forward bias voltage into the adsorbates on a surface of the catalyst ~~catalytic collector~~. With the methods and apparatus provided in this invention, the energy of the injected electrons may be chosen by the user so as to steer reactions and to drive reactions in selected modes or pathways, including reaction paths inaccessible to thermal processes.

Please replace the paragraph beginning on page 14, line 1 as follows:

~~Another novel aspect of the present invention is the reversible nature of the present invention.~~ In another embodiment, the method and apparatus of the present disclosure may be reversible. For example, the inverse of the stimulation process is the collection of electrons generated by adsorbates reacting on the catalytic excitation collector and the resonant coupling of energy into the semiconductor diode, creating carriers such as conduction band electrons or valence band holes. The ~~catalytic collector~~ catalyst, one embodiment, acts like a collector of hot electrons generated by adsorbate chemical reaction energy ~~instead of a collector of hot electrons generated by the hot carrier emitter~~. ~~The catalytic collector~~ In one embodiment, the catalyst, for example, a conducting catalyst, couples excitations from the adsorbates to the semiconductor, instead of from the semiconductor to the adsorbates. ~~The hot carrier emitter gets its hot electrons from the catalytic~~

~~collector instead of from the diode junction.~~ The p-type region of the semiconductor gets its hot carriers from the catalyst instead of from the n-type region of the semiconductor. The hot carriers in the p-type region may be excited ~~emitter may generate its electrons~~ by resonant coupling of energy from the excitation structure of the adsorbate-catalyst system. The hot carriers migrate ~~electrons go~~ into the diode junction towards the n-type semiconductor base ~~instead of out of the diode junction from the base~~. In so doing, the hot electrons maintain a forward bias on the diode, thereby generating electricity. This reversible nature ~~of the present invention~~ permits the device to generate electricity as a direct result of chemical reactions. This is a generator mode.

Please replace the paragraph beginning on page 15, line 11 as follows:

~~When the device is operated in the stimulator mode, energy~~ Energy may be collected in any manner including by operating the solid state surface catalytic reactor in the generator mode. Other modes of collecting energy include but are not limited to collecting radiations emanating from reactions that have been stimulated, or by collecting heat, or by collecting the reaction products themselves, or by capturing the kinetic energy of the products as they desorb, or by collecting the phonons, or by stimulating and collecting coherent acoustic or optical radiation, or by stimulation of piezoelectric devices.

Please replace the paragraph beginning on page 15, line 31 as follows:

With the p-n junction semiconductor in the present invention, semiconductors with band gaps starting from approximately 0.05 eV to 5 eV may be used with room temperature heat sink operation, and band gaps less than 0.05 eV may be used

when the system is operated at lower than room temperature. This does not preclude using materials with higher bandgaps, such as insulators like CaF2 with 12 eV bandgap, or any other material with higher bandgap. In particular, the commonly used InSb and InGaAsSb materials have band gaps that may be continuously chosen in the range 0.1 to 1.5 eV by suitable choice of the In / Ga ratio and the As / Sb ratio. The resulting ranges of band gaps lie precisely in the range of energies associated with hydrocarbon chemical bonds. The InSb material produces 0.18 eV electrons, which is ideal for favoring reaction stimulation Vs desorption, because higher energy electrons may stimulate an undesirable large fraction of desorptions, as opposed to surface reactions.

Please replace the paragraph beginning on page 16, line 14 as follows:

The p-n junction embodiment of this invention provides a substrate whose energy levels match the excited state energy levels of the adsorbates. This greatly enhances resonant transfers, in either direction, that is, to or from the adsorbate. The metals of the catalytic excitation collector provide a resonant tunneling coupling, for example, via plasmons, between the adsorbate and the semiconductor substrate. The resonant tunneling coupling effectively connects the energy band structure of the substrate to the energy band structure of the adsorbates. An ohmic or almost ohmic junction between the ~~catalytic collector~~ catalyst and the semiconductor effectively pins the Fermi level of the ~~catalytic collector~~ catalyst to the valence band of the semiconductor. The lower edge of the conduction band of the semiconductor, being higher than the valence band by an amount equal to the band gap of the semiconductor, ~~then appears~~ in one embodiment is above the Fermi level of the ~~catalytic collector~~ catalyst by the same amount,

namely the band gap energy. Since the bandgap may be chosen from a palate between 0.05 to 5 eV, the bandgap energy may be made to match nearly any energy level of the system having the adsorbate and the catalytic excitation collector. By choosing the semiconductor band gap to match the energy level of an adsorbate on the catalytic excitation collector, one may effectively couple the two together through the well known and commonly used process of resonant tunneling. Resonant tunneling greatly increases the cross section for the transfer of energy.

Please replace the paragraph beginning on page 17, line 6 as follows:

This is useful in the stimulator mode to steer reactions because selected energy levels of the adsorbate may be resonantly activated by hot carriers coming from the semiconductor. This is useful in the generator mode because excited vibration states of adsorbates may be coupled resonantly to the semiconductor, enhancing energy transfer. This is useful in the stimulator-generator mode because the stimulator can trigger and initiate adsorbate reactions, using a relatively small stimulator energy, and the reactions may then spread in a manner analogous to an explosion or detonation on the surface catalytic excitation collector exposed to reactants, which release hot carriers. The hot carriers may then generate electricity at a rate faster than they loose energy by generating heat.

Please replace the paragraph beginning on page 19, line 4 as follows:

For example, the present invention is directed to a method and apparatus for making a device that will generate hot carriers, especially hot electrons, transport them and couple them to reactant adsorbates on a catalyst surface and cause such adsorbates to acquire an effective vibrational temperature in

excess of the temperature of the catalytic surface. ~~Vibrational energy and temperature are used interchangeably. Energy is the product of the Boltzman constant and absolute temperature.~~ Such an effective vibrational temperature in turn accelerates the reaction rates on the catalyst. Excited vibrational states of atomic and molecular adsorbates, both against the catalyst surface and internal to the adsorbates, are observed to be orders of magnitude more reactive than adsorbates in ground states. The methods and apparatus of the present invention increase adsorbate vibrational energy or temperature using an electrical stimulus without appreciably increasing the substrate thermal energy or temperature.

Please replace the paragraph beginning on page 19, line 23 as follows:

In another aspect, the present invention is directed to methods and apparatus for reversing the above-described process, wherein one or more excitation energies, electrons or holes generated by chemical reactions described herein above are ~~converted~~ coupled into a semiconductor substrate and converted into electricity.

Please replace the paragraph beginning on page 19, line 29 as follows:

~~Accordingly, one aspect of the present invention is directed to a reaction stimulator method and device to use electricity to create energetic carriers, particularly hot electrons, in a hot carrier emitter and inject those carriers efficiently into a catalytic collector. Preferably, the catalyst or substrate temperature need not be raised during the reaction stimulation.~~

Please replace the paragraph beginning on page 20, line 1 as follows:

In another aspect, the present invention is directed to methods and apparatus for a reaction stimulator - generator that efficiently collects energetic carriers generated by reactions on a catalyst surface, particularly hot electrons, and causes them to charge a forward biased diode through an emitter-base junction, thereby generating electricity.

Please replace the paragraph beginning on page 20, line 8 as follows:

In another aspect, the present invention is directed to a reaction stimulator that injects hot carriers or hot electrons with the range of energies needed to selectively favor desired types of surface chemical reactions. ~~Preferably, the reaction stimulator is simple in design, rugged in construction, and economical to manufacture.~~

Please replace the paragraph beginning on page 20, line 24 as follows:

~~Accordingly, the method to stimulate reactions includes using electrical energy to forward bias a semiconductor diode, wherein an electric potential across the electrical contacts of the semiconductor diode creates hot carriers such as hot electrons that diffuse out of the diode junction and are transported through the catalytic collector to the chemical adsorbate, thereby stimulating the adsorbate to react.~~

Please replace the paragraph beginning on page 20, line 32 as follows:

~~Accordingly, the method to generate electricity includes creating hot carriers in the catalytic collector using chemical adsorbate reaction energy and transporting or coupling the hot~~

~~carriers into the junction of the semiconductor diode, causing the diode to become forward biased and thereby generating electricity.~~

Please replace the paragraph beginning on page 21, line 3 as follows:

~~The method also includes utilizing a carrier diffusion process that transports the energetic carriers such as hot electrons to and from the diode junction to the catalytic collector.~~

Please replace the paragraph beginning on page 21, line 7 as follows:

~~The method also includes using a catalytic collector either to collect hot carriers provided by the emitter to transport or couple them to a chemical adsorbate on a catalyst surface or to optional reaction accelerator decelerator materials, or, the reverse process, to collect hot carriers generated by the chemical adsorbate on a catalyst or optional reaction accelerator decelerator materials and transport or couple them to an emitter.~~

Please replace the paragraph beginning on page 21, line 15 as follows:

The method also includes forming metal clusters, layers, atomically uniform monolayers, surface structures, crystalline layers or 1, 2 or 3 dimensional quantum confinement structures such as quantum dots, quantum stadia, quantum corrals and quantum wells from materials comprising the catalyst ~~catalytic collector~~. The method includes using such layers and quantum confinement structures to tailor the density of electron and hole states of the materials, which in turn cause favorable conditions for the formation of or reaction with hot carriers. Such conditions

include depletion of the number of electrons available for the decay of vibrational energies of the adsorbate-substrate system with values of transition energy less than that of the bandgap of the substrate.

Please replace the paragraph beginning on page 21, line 29 as follows:

~~This invention~~ The method and apparatus of the present disclosure in one embodiment includes a surface catalyst reactor with tailored electron density of states and tailored energy decay modes. For example, the electron density of states may be modified by forming ordered, electron-reflective or hole-reflective structures of material on the catalyst ~~catalytic collector~~ surface exposed to reactants.

Please replace the paragraph beginning on page 22, line 1 as follows:

The method in one embodiment ~~this invention~~ includes tailoring the carrier density of states near the Fermi surface of the ~~catalytic collector~~ catalyst so as to enhance the probability of forming electron-hole pairs with the desired energy distributions and for enhancing stimulation of resonant tunneling coupling of vibration states of the adsorbate-substrate system. Such tailoring may include forming and tailoring of the hot electron Fabrey-Pérot modes of a thin-film electron interferometer.

Please replace the paragraph beginning on page 22, line 17 as follows:

The method also may include using combinations of different catalyst materials and of optional reaction accelerator-decelerator materials as part of the catalytic excitation collector, and of forming such materials in any geometry,

including but not limited to pillars, islands, clusters, interdigital and random structures and stripes.

Please replace the paragraph beginning on page 23, line 8 as follows:

~~The method also includes using pulsed stimulation. Pulsed operation stimulates the reactions to occur with high peak power and short duration. This permits the device to remain relatively cool during the longer periods of zero stimulation after the reactions have completed and it permits the reactions to occur at a high temperature and high peak power during the relatively short periods of pulsed stimulation. Pulsing allows reactions to occur before thermal processes cause the reactions to occur. Pulsing permits the complete depletion of reactants in a time shorter than they can be replenished by the reactant gas mixture, that is, through gas kinetic means.~~

Please replace the paragraph beginning on page 23, line 20 as follows:

The method in one embodiment also includes using an optional underlayer material as part of the catalytic excitation collector. The underlayer may be a metal such as copper, gold, silver or aluminum, and is chosen to be compatible with obtaining the desired properties with the semiconductor component of the hot carrier emitter. One desired property is an ohmic or almost ohmic junction. The underlayer may be used as an electrical connection in the hot carrier emitter and may also be used as an electrical connection to the catalytic excitation collector. The underlayer may be used as a substrate upon which to fabricate catalyst structures, more underlayers or specified geometries and crystal orientations of materials deposited as part of the catalyst ~~catalytic collector~~, or to tailor the lattice constants of materials deposited on the underlayer.

Please replace the paragraph beginning on page 24, line 8 as follows:

The method includes enclosing all or selected components of the device in an optical cavity tuned to an energy associated with the excitation structure of the semiconductor, or of the catalytic excitation collector or of the adsorbates or of some combination of these elements.

Please replace the paragraph beginning on page 24, line 13 as follows:

~~An apparatus to stimulate reactions or to generate electricity according to the present invention includes a hot carrier emitter and a catalytic collector. The hot carrier emitter belonging to this apparatus includes a semiconductor diode. The semiconductor diode includes a semiconductor base, a diode junction also called an emitter base junction, and an emitter. The emitter includes a semiconductor or a metal as a diode element. The apparatus may also include a first electrical connection to the emitter and a second electrical connection to the base.~~

Please replace the paragraph beginning on page 24, line 23 as follows:

An apparatus to stimulate reactions or to generate electricity according to one embodiment of the present disclosure includes a hot emitter and catalyst surface. ~~An~~ The apparatus in one embodiment ~~to stimulate reactions or to generate electricity according to the present invention~~ may include an optional optical cavity tuned to a desired energy level transition of either the excitation structure of the semiconductor or of the system including the catalyst ~~catalytic collector~~ and chemical

adsorbate. Such cavities may include and are not limited to metal and dielectric microcavities, periodic structures that exhibit photonic band gap properties, fabrey-perot cavities, textured mirrors, distributed Bragg reflectors, single and coupled semiconductor microcavities, external cavities with a wavelength filter or a large dispersion, quantum dot vertical cavities, microdisk cavities, quantum dot microdisk cavities, laser waveguides with or without cladding, dielectric slab waveguides, cavities associated electromagnetic surface waves, also called surface plasmons, at a metal-semiconductor interface where no additional confinement layer is needed, chaotic resonators, optical resonators with deformed cross section, resonator designs that incorporate chaotic ray motion, and symmetric resonators with whispering-gallery modes.

Please replace the paragraph beginning on page 25, line 9 as follows:

In one embodiment, the hot carriers are electrons, the diode is a p-n junction made of InSb with n type base and p type emitter and the catalytic excitation collector is located or co-located in the proximity of the emitter electrical contact. The catalyst ensemble includes a catalyst metal such as any alloy of platinum and palladium and deposited in a surface structure, cluster or quantum confined structure. The configuration or geometry of the catalyst, for example, is such that the distance to the semiconductor from regions of catalyst exposed to adsorbates is predominantly less than 3 times the energy mean free path in platinum, which mean free path is approximately ~~20~~ 10 nm. The catalyst metal is in direct contact with the semiconductor of the emitter, which semiconductor is degeneratively doped to form an ohmic or tunneling junction. In this embodiment, the p-n junction is formed a distance from the catalytic excitation collector that is less than 3 times the

diffusion distance for electrons in the conduction band of p type InSb, which diffusion distance may be as little as 200 nanometers. The device may be operated in the stimulator mode, the generator mode or the stimulator-generator mode, and where the hot electrons may be created either by the chemical adsorbate reactions or by electrical energy input to the semiconductor diode.

Please replace the paragraph beginning on page 25, line 33 as follows:

~~The reversible solid state surface catalysis excitation transfer reaction apparatus in the present invention couples the excitation band structures of the adsorbate catalyst system with the excitation band structure of the semiconductor substrate. The apparatus may be designed to operate on gaseous reactants. In the generator mode, the energies of excitations associated with chemical reactions of adsorbates on and with the surface of a catalytic collector are converted into excitations such as hot carriers and electromagnetic fields.~~

Please replace the paragraph beginning on page 26, line 8 as follows:

~~The energies of excitations associated with reactions of adsorbates include excited reactant molecular vibrations molecule surface vibrations, atom surface vibrations, adsorption reactions, chemical reactions and excited electronic states. The converted excitations such as hot carriers and electromagnetic fields are transported to the excitation emitter where semiconductor or emitter excitations are created and may be converted into useful forms of energy. The emitter excitations include minority carriers, hot carriers, carrier diffusion, coupling electric fields, excitons, and plasmons in the~~

~~semiconductor.~~

Please replace the paragraph beginning on page 26, line 20 as follows:

~~Also, in the generator mode, pulses of excitation energies associated with chemical reactions of adsorbates occurring on and with the surface of a catalytic collector, such as excited reactant molecular vibrations, molecule-surface vibrations, atom-surface vibrations, adsorption reactions, chemical reactions and excited electronic states, may be converted into excitations such as hot carriers and electromagnetic fields. These excitations are transported to an emitter or the excitation emitter where excitations such as minority carriers, hot carriers, carrier diffusion, coupling electric fields, excitons, and plasmons in the semiconductor are created and may be converted into useful forms of energy.~~

Please replace the paragraph beginning on page 26, line 33 as follows:

~~In one embodiment, the excitation emitter and the catalytic collector may share a component common to both of them.~~

Please replace the paragraph beginning on page 27, line 1 as follows:

Figure 1 illustrates a general schematic cross section of a solid state surface catalysis reactor device, in one embodiment. The device 100 comprises ~~a~~n hot carrier emitter 102 and a catalytic excitation collector 104, formed on a base 108. A semiconductor p-n junction 110 is formed between the hot carrier emitter 102 and the base 108. An ~~emitter~~ electrical connection 114 and catalytic excitation collector of hot electrons 104 are arranged as shown in Figure 1. A base electrical connection 112

is also arranged in contact with the base 108 as shown in Figure 1. Reactants and products interact on the catalyst surface 116 of the catalytic excitation collector 104. The reactants may include but are not limited to the hydrocarbon chains, ethane, ethylene, propane, propylene, propene, butane, butene, cetane, isomers thereof.

Please replace the paragraph beginning on page 27, line 15 as follows:

In the stimulation mode, the device 100 utilizes electrical energy to create energetic carriers, also referred to as hot carriers or hot electrons. The hot carriers diffuse into the catalytic excitation collector 104, interact strongly with reactants on the catalyst surface 116 and accelerate the reactions to produce reaction products. The stimulated reactions may cause a chain reaction or the equivalent of a surface explosions. The stimulated reactions may also cause an autocatalyzed chain reaction.

Please replace the paragraph beginning on page 27, line 29 as follows:

In ~~an exemplary~~ one embodiment, a p-n junction ~~is used~~ with p type emitter and n-type base is forward biased to create hot electrons. ~~Accordingly, the junction 110 may be forward biased. When the hot carrier is a hot electron, as opposed to a hot hole, the junction may be a p-n junction with p-type emitter and n-type base.~~ Alternatively, the junction may be a Schottky junction with a metal hot carrier emitter and n-type semiconductor base.

Please replace the paragraph beginning on page 28, line 3 as follows:

In the stimulation mode, the forward biased junction 110

creates hot electrons. For example, when the base contact 112 is biased negative and the emitter contact 114 is biased positive, hot electrons are created in the junction 110. The hot electrons diffuse through the emitter 102 and ballistically transport through the catalytic excitation collector 104 to the catalyst surface 116.

Please replace the paragraph beginning on page 28, line 10 as follows:

In the generator mode, hot electrons originating on the catalyst surface 116 may also ballistically transport through the catalytic excitation collector 104 and diffuse to the junction 110, causing the emitter-base junction diode 110 to become forward biased The diode then may become an electricity source instead of a sink.

Please replace the paragraph beginning on page 28, line 15 as follows:

~~For example, when hot electrons transport and diffuse from the catalyst surface 116 to the junction 110, the base contact 112 becomes biased negative and the emitter contact 114 becomes biased positive, and the diode in the present invention becomes an electron source instead of a sink.~~

Please replace the paragraph beginning on page 28, line 20 as follows:

~~These hot electrons migrate or diffuse to or from the emitter 102, and to or from the catalyst surface 116. Accordingly, in an exemplary~~ In one embodiment, the distance from the diode junction 110 to the adsorbates on the surface of the catalyst 116 is formed to be less than the distance over which the energy of ~~these carriers~~ hot electrons degrades. This distance is generally less than several times the energy mean

free path of such energetic hot electrons when evaluated over the path from the emitter-base junction 110 to the adsorbates on the catalyst surface 116.

Please replace the paragraph beginning on page 28, line 30 as follows:

Using the process described herein above, reactants adsorbing on the catalyst surfaces become vibrationally and/or electronically excited by the hot electrons, which excitation accelerates the reaction and forms products. ~~Using these means, hot electrons created by the reactants adsorbed on the collector catalyst ensemble create a potential in the forward biased diode.~~

Please replace the paragraph beginning on page 29, line 3 as follows:

In ~~an exemplary~~ one embodiment of the present disclosure ~~invention~~, the catalytic excitation collector 104 includes catalyst materials in layers, clusters, atomically uniform monolayers, or surface structures. Preferably, the layers or clusters have thickness dimension less than several times the total energy mean free path of hot electrons in the catalyst. The layers or clusters are formed close enough to the diode junction 110 such that hot electrons may diffuse directly between the junction 110 and the catalyst surface 116.

Please replace the paragraph beginning on page 29, line 12 as follows:

The total energy mean free path of hot electrons in catalysts such as platinum or palladium is of order 10 ~~20~~ nanometers and is ~~far~~ shorter than in Au, Ag or Cu. Therefore, according to an exemplary embodiment, catalyst clusters or layers are fabricated with cluster, layer thickness or thickness dimension less than this smaller value. For example, the

electron energy lifetime has been measured in Tantalum, a representative transition metal electronically similar to the platinum group, and is of order 15 fs. The calculated lifetime in palladium based on the Fermi inverse square scaling would be 600 fs at 0.3 eV and giving a total energy mean free path of 840 nanometers. Instead of this optimistic large value, it is presumed the lifetime is as poor as that measured in tantalum. This gives a total energy mean free path in platinum or palladium of order 21 nanometers. In this embodiment, the catalyst dimension is less than the measured energy mean free path of the hot electrons. These arguments concerning the total thickness of an underlayer, which is the electrical connection to the catalyst, and the catalyst, are only to assert that the path taken by the hot carrier through such catalyst and underlayer shall not be so long as to significantly degrade the hot carrier energy, and any dimension satisfying this condition is acceptable.

Please replace the paragraph beginning on page 30, line 1 as follows:

~~Preferably~~ In one embodiment, some reactions in the method and apparatus of the present disclosure may occur before thermal desorption occurs. In one embodiment, the methods provided ~~in the present invention~~ generate electrons that have energies in the range that favor reaction over desorption. These energies are in the range 0.05 to 0.4 eV. Similarly, the method to collect electrons generated by chemical reactions on the catalyst surfaces collect electrons whose energies are also in the range of 0.05 to 0.4 eV. Accordingly, a semiconductor material with band gap less than approximately 0.4 eV may be used. Examples of such semiconductor material include indium antimonide (InSb) or indium arsenide (InAs) which have band gaps of 0.18 eV and 0.35 eV, respectively. Many semiconductor alloys provide acceptable

bandgap energies.

The energetic electrons produced with these semiconductors have energy approximately equal to the band gap in the p type semiconductor emitter. Hot electrons diffusing back into the n-type base generate electric potentials whose magnitude approaches the band gap energy. The method of the present disclosure may include choosing ~~Generally,~~ the value of the band gap ~~is selected~~ based on the nature of the reactants and the energies associated with their surface activity.

Please replace the paragraph beginning on page 30, line 20 as follows:

In ~~an exemplary~~ one embodiment, the catalyst clusters may further include activators, de-activators, decelerator or accelerators placed in their proximity, such as oxides or other materials, as shown in cross section in Figure 2. Figure 2 illustrates a cross section 200 of a catalytic excitation collector including reaction accelerator-decelerator materials 206 adjacent to and co-located with the catalyst materials 202. As shown, the hot electron catalytic excitation collector includes the catalyst materials 202, an optional thin electrode underlayer 204, and reaction accelerator-decelerator materials 206 such as oxides. For example, oxides of the catalyst itself, of cerium, titanium or aluminum may be formed between the catalyst islands or layers. The total dimension of the catalyst 202 and thin electrode underlayer 204 is preferably less than several times the total energy mean free path of a hot electron.

Please replace the paragraph beginning on page 31, line 1 as follows:

Figures 3, 4, and 5 illustrate several different embodiments of the catalytic excitation collector used in a solid state surface catalysis reactor ~~of the present invention~~. As shown in

the Figures, the catalytic excitation collector may include catalyst material such as islands 302 that reside directly on the semiconductor (Figure 3), or of catalysts 404 on a thin electrode underlayer 402 (Figure 4) which also forms the electrical connection for the hot carrier emitter 414, or catalysts 404 (Figure 5) with reaction accelerator-decelerator materials 502 surrounding or adjacent to the catalysts, all residing on a thin electrode underlayer 402 which also forms the electrical connection for the hot carrier emitter 414~~(Figure 5)~~.

Please replace the paragraph beginning on page 31, line 22 as follows:

Figure 3 shows a cross section 300 of the solid state surface catalysis reactor device ~~comprising a hot carrier emitter~~ where the hot carrier is an electron~~, a catalytic collector~~. The catalytic excitation collector ensemble 302 includes catalyst islands 302, preferably formed such that the distance to the semiconductor 304 is less than the three times the total energy mean free path of the hot electron in the catalyst 302. ~~Preferably, the~~ The catalyst islands 302 are bonded directly to the p doped or heavily p doped, p+ region of the semiconductor 304. In one embodiment, the catalyst materials 302 are spread over the surface of the semiconductor. In another embodiment, the catalyst is formed with surface structures containing atomically uniform monolayers.

Please replace the paragraph beginning on page 32, line 1 as follows:

The ~~hot, for example, electron, carrier~~ emitter of hot electrons includes the semiconductor diode formed by negative electrode 306 in contact with n type semiconductor 308, p type semiconductor 312, p-n junction 310 formed between the n type semiconductor 308 and the p type semiconductor 312, p doped or

heavily p doped p+ semiconductor 304, and positive electrode 314.

Please replace the paragraph beginning on page 32, line 8 as follows:

Figure 4 illustrates a cross section 400 of a solid state surface catalysis reactor device with thin electrode 402 forming a substrate for catalyst structures. In this embodiment, the catalytic excitation collector includes a thin electrode underlayer 402, catalyst structures 404 and a bus bar electrical connection 406 in electrical contact with the thin electrode underlayer 402. The hot electron emitter includes a semiconductor diode formed by negative electrical connection 408, n-type semiconductor 410, p-n junction 412, p type semiconductor 414, p doped or heavily p doped p+ semiconductor 416, and thin electrode underlayer 402. As shown, the thin electrode underlayer 402 may be common to the hot electron emitter and the catalytic excitation collector. The thin electrode underlayer 402 may be a thin positive electrode. The thin electrode underlayer 402 is preferably selected from those materials that make an ohmic or almost ohmic junction to the semiconductor.

Please replace the paragraph beginning on page 33, line 7 as follows:

For ~~0.3 eV~~ hot electrons that have 0.3 eV energy and that will come in contact with commonly used contact metals such as silver ("Ag"), gold ("Au"), and copper ("Cu"), the electron energy lifetime exceeds 200 femtoseconds and the electron velocity is of order 1.4e6 meters/second. The resulting energy mean free path is therefore of order 280 nanometers. This permits the underlayer electrical contact to the semiconductor to be an order of magnitude thicker than the catalytic excitation collector and enhances manufacturability. Thin, 1 to 5 nanometer ("nm") layers of Au, Ag and Cu conductors are routinely

fabricated on semiconductors, permitting a thin layer to form the ohmic or almost ohmic contact with semiconductor. This thin layer, e.g., the thin electrode 402, assures that the Fermi level of the catalyst and the Fermi level of the p type semiconductor emitter are the same or practically the same. In this embodiment, a thin, 1 to 20 nm layer of metal such as Au, Ag or Cu may be used as the electrode 402 or substrate for the catalyst ensemble. It should further be appreciated that the present invention does not limit the choice of contact metal used to form the electrode to Au, Ag or Cu, and other metals, alloys or semi-metals may be selected to form at least a nearly ohmic junction with the semiconductor.

Please replace the paragraph beginning on page 34, line 16 as follows:

As an example, a preferred doping of 2e19 per cc donors in InSb or InAs is considered to be such a heavy doping. Degenerative doping of the semiconductor to 2e20 per cc and bonding a suitable metal, such as Au, Ag, or ~~eu~~ Cu, as the thin metal contact can make an almost ohmic electrical connection to the semiconductor. Nearly any metal may form such an almost ohmic junction because the junction dimension under heavy or degenerative doping is of order 1 nanometer or less, and at this dimension tunneling across the junction is predominating. A junction of this type typically has characteristic p-n junction dimension of order 3 nanometers or less and electron diffusion length in the emitter and collector regions in excess of 1 micron. The dimension may be limited by Auger recombination. Therefore, the junction between the emitter and the catalytic excitation collector elements of the present invention can be readily constructed since .1 micron thickness and greater dimension is routinely achieved in practice.

Please replace the paragraph beginning on page 34, line 34 as follows:

The thin electrode is bonded to the p type semiconductor surface. The catalyst clusters or layers are placed on the thin electrode and preferably near to the p-n junction. "Near" is defined to be "a distance that is within the diffusion dimension of minority carriers in the emitter semiconductor." This dimension is typically of order 0.1 micron or more. The calculated diffusion length of electrons in p type InSb doped to 2e20 per cc is of order 7 microns and 5.5 microns in InAs. However, observed Auger lifetimes of 1 picosecond suggest the diffusion length is of order 1 micron. As will be appreciated by those skilled in the art, this dimension is well within current manufacturing state of the art. Accordingly, the catalyst metal 302 and 404 or the thin metal contact underlayer 402 may serve as both the catalytic excitation collector and an emitter positive electrical connection. This also reduces the cost and complexity of fabrication.

Please replace the paragraph beginning on page 35, line 16 as follows:

Figure 5 shows a cross section 500 of a solid state surface catalysis reactor device similar to that illustrated in Figure 4 and with reaction accelerator-decelerator materials 502 surrounding or adjacent to catalyst structures 404. As described with reference to Figure 2, in an exemplary embodiment, the catalyst clusters may further include chemical surface reaction activators, accelerators or decelerators placed in their proximity, such as oxides or other materials. As shown, the catalytic excitation collector includes the catalyst structures 404, an optional thin electrode underlayer 402, and catalyst accelerators or decelerators 502 such as oxides. For example, oxides of the catalyst itself, or oxides of cerium, titanium or

aluminum may be formed between the catalyst islands or layers. The distance a hot electron must travel through the catalyst 404 and thin electrode underlayer 402 is preferably less than several times the total energy mean free path.

Please replace the paragraph beginning on page 35, line 34 as follows:

Figure 6 shows a cross section 600 of the solid state surface catalysis reactor device including a single metal element 605 that is at the same time an electrical connection to the emitter, the underlayer of the catalytic excitation collector and forms the metal element of a Schottky diode.

Please replace the paragraph beginning on page 36, line 4 as follows:

Shown in Figure 6 is a solid state surface catalysis reactor device using a Schottky diode. Reactants adsorb on the catalytic excitation collector 605~~, 606~~ and 607. A Schottky diode is formed between the thin metal underlayer 605, the more heavily doped semiconductor 604 shown as n type for illustration appropriate for the hot carrier being hot electrons, the lesser doped semiconductor region 601, and the thicker negative electrical connection 606. Bus bar 602 provides the electrical connection for the current-carrying, positive, thin electrode 605. In operation, the diode is pulsed with a forward bias, that is, electrode 606 is pulsed negative with respect to positive electrode 605, consuming electric power. This triggers surface reactions on the catalyst ensemble 607 and causes products to be formed.

Excess reaction energy may cause the device to operate in generator mode. Here, excess hot electrons produced by the reactions may produce a burst of hot electrons which travel through the thin catalyst structure 607 and element 605, surpass

the Schottky barrier potential and enter the diode regions 601 and 604, forward biasing the diode and producing electric power.

Please replace the paragraph beginning on page 36, line 23 as follows:

The reversible nature of this embodiment is shown for illustration. The reaction stimulation properties of the same device may be its principle function, or the ~~. The~~ electrical generation properties may be the principle function.

Please replace the paragraph beginning on page 37, line 17 as follows:

In this and all other embodiments, the effectiveness of the stimulator, generator and reactor may be ~~greatly~~ enhanced by providing reactants in the gas phase. In this case, the adsorbates on the catalyst surface interact with the hot carriers. When a liquid covers the catalyst, multiple layers of adsorbate absorb the hot electron and diminish its effectiveness. ~~Thus, a point of novelty of this invention also include the use of~~ In one embodiment, forward biased devices may be used for the purpose of reaction stimulation or electric generation.